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INTEGRATED RF SENSOR SIGNAL/DATA PROCESSING INFORMATION ANALYSIS CENTER (IAC)

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1.0 INTRODUCTION

AFRL/SNRT, the Radar Signal Processing Branch, has as its mission the development of technology to enhance advanced target detection, track and handoff from long-range standoff airborne, space-based and intelligence, surveillance, reconnaissance platforms and reduced false alarms through the mitigation of clutter and jamming. This is accomplished by a program of development and implementation of advanced signal processing algorithms, analysis tools and techniques. Over the years, and as a result of their work, AFRL/SNRT and its supporting contractors and other collaborating organizations, have amassed an enormous body of domain specific information. Examples of this type of information include algorithms for signal and data processing, processor designs, measured data from sensors implemented with advanced sensor and processor technology, MATLAB tools, etc. This body of information resides in many places and in many forms (hardcopy reports, computer codes, journal articles, symposia records, various electronic databases, etc.). New domain specific information is continuously generated and as a result, the "collection" grows steadily.

Unfortunately, this "collection" is so massive, it is neither managed nor organized, and therefore is not available in any unified and cohesive manner; that is to say, there does not exist a single authoritative information source related to RF signal processing. One finds that the elements that comprise the "collection" are scattered to and fro. This raises the following questions: Is there value in establishing an entity that is responsible for the systematic and unified collection, storage, analysis and dissemination of this body of information? Does a market exist for this type of information and related services, if properly packaged and made available from a single source? We believe the answer to both questions is affirmative. It is our opinion that if properly organized, such an entity would be of great value to system developers, mission planners, and program offices as they carry out their responsibilities in the area of RF sensor development and implementation. Furthermore, we believe that the establishment of such a center of excellence, operating in concert with AFRL/SNRT's existing program, would bring additional credibility and focus on the organization as it positions itself to be the premiere source of radar signal processing technology for the DoD.

The DoD has a formal program in place that recognizes the need to locate, organize, and use scientific and technical information in a variety of technology disciplines. This program is known as the DoD Information Analysis Center (IAC) program. In the next section, a short overview of this program is presented and sets a baseline for the proposed radar signal processing IAC.

2.0 INFORMATION ANALYSIS CENTERS

It is well known that the DOD sponsors a number of information centers, formally known as Information Analysis Centers (IACs). The mission of the IACs is to serve the Scientific and Technical (S&T) community as repositories and clearinghouses for domain specific information in a number of important technology areas. (A

complete description of these centers can be found at www.dtic.mil/iac/). The IACs are government organizations regulated by DoD Directive 3200.12; DoD Scientific Technical Information (STI) Program (STIP), dated 11 February 1998; and DoD Instruction 3200.14, Principles and Operational Parameters of the DoD Scientific and Technical Information Program, dated 13 May 1997. The Defense Technical Information Center (DTIC) administratively manages thirteen contractor-operated IACs. Ten others are managed by other DoD activities. Those IACs that are under the DTIC umbrella receive what is known as core funding from DTIC. This core funding, which is in the range of several hundred thousand to one million dollars per year, is for the basic operation of the IACs. Additional funding, derived from the sale of products to the appropriate user community, can result in sales for the IAC that can range up to $10M per year.

The Office of the Secretary of Defense, Director of Defense Research and Engineering provides policy oversight of the IACs. Administrative and operational management is provided through the Defense Information Systems Agency (DISA) by DTIC. Technical management is provided by an appointed Contracting Officer's Technical Representative (COTR) from technical host organizations.

IACs help technology developers investigate and understand functional requirements and technological capabilities and help the warfighters understand how to use, train for, and maintain new technologies. They serve as a central source of research, development, and testing information and help facilitate teamwork between technology developers and warfighters. IACs also hold symposia, workshops, and conferences to bring all the relevant parties together. Technology developers, warfighters, and program managers can simply call the appropriate IAC to learn about the industrial and defense organizations, analysis tools, advanced technology and research, testing, evaluation, and training methods that can best contribute to fulfilling their mission.

Program managers can capitalize on the specific skills of their staff and maximize their tight budgets by utilizing the unique and specialized skills of the IACs. The IACs provide program managers with affordable short- and long-term analytical services using premiere commercial and government scientific and technical databases, government lessons-learned databases, and internally developed special-need databases. IAC staff members can help prevent unnecessary duplication of work by locating and analyzing data, information, and tools that were used in the development of similar systems throughout the world. IAC analytical services can also help scientists in basic research efforts by uncovering the necessary background data and information and in identifying problem areas of critical interest to the warfighter.

In the next section, the framework for an IAC specializing in radar data and signal processing is presented. Essential elements such as specific tools and databases are discussed and a conceptual block diagram that integrates these elements is proposed.

3.0 INTEGRATED RF SENSOR SIGNAL/DATA PROCESSING INFORMATION ANALYSIS CENTER

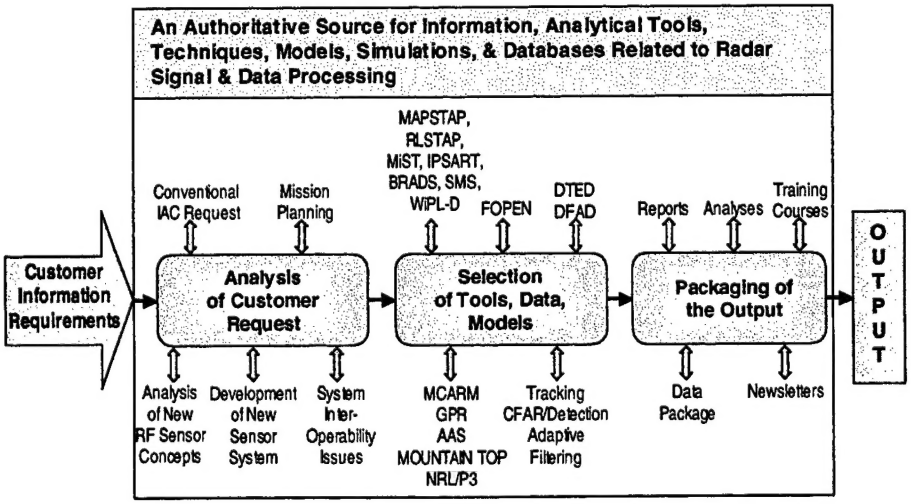
Once established, the proposed center would serve as a repository and clearinghouse for radar signal and data processing related information as well as an organization to perform user requested analyses, studies, and other technical tasks. The center would collect, store, maintain, analyze, and disseminate information, tools, data, and techniques. The products of the center would be delivered in a variety of formats such as hardcopy reports, CD-ROMs, via the Internet, etc.

3.1 Key Elements

There are a number of key elements that would be a necessary part of the proposed IAC. They are:

- High fidelity analysis tools (simulations) such as RLSTAP and WIPL-D.
- Sensor specific system level databases (MCARM, GPR, NRL/P3, Mountaintop, FOPEN, AASP, TTRDP, APTI).
- Component level databases (T/R module data, tube specs)
- Environmental/cultural databases (DTED, DFAD, land use/land cover).
- Advanced signal processing algorithms (tracking, CFAR/detection, adaptive filtering) in an open system architecture (advanced portable algorithms, MAPSTAP).
- Technical staff to perform customer-funded special analyses (Technical Area Tasks).
- Short-term courses (invited staff plus resident staff).
- Newsletters, state-of-the-art reports, critical reviews and technology assessments, web-based broadcast information.
- Symposia, workshops, and conferences.

The following diagram provides a high level view of those elements and their interrelationships.



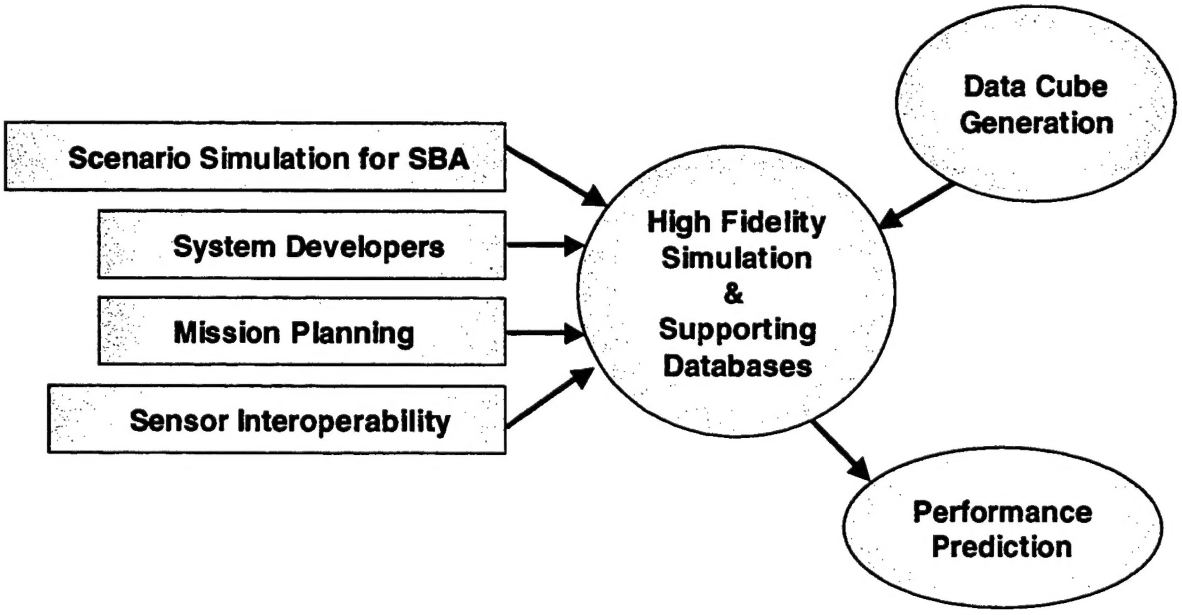
3.2 Functionality

We envision a facility that serves the following users and uses:

- Analysis of RF sensor concepts (MITRE, Lincoln Labs, Aerospace Corp., etc.)
- System developers (Raytheon, Lockheed, etc.)
- Mission planners (flight planning, etc.)
- System interoperability (geometric location, frequency allocation, integrated modes of operation, etc.) when planning the integration of existing systems or the integration of new systems under simulation based acquisition (SBA).

In this operating mode, users would be able to access the full set of tools, models, algorithms, databases, and so on to enable them to evaluate their proposed sensor concepts and designs. Mission planners would be able to test out proposed operating plans as well as exercising what-if scenarios. System interoperability issues could be studied via the exercise of the IAC repertoire of tools and it is anticipated that the assets of the center would be web accessible. It is proposed that in this operating mode, cost reimbursement would be on a subscription or pay for services basis.

A typical workflow is illustrated in the following notional diagram.



4.0 Specific Tasks:

Inherent in the mission of all DoD IACs is the collection, processing and management, analysis, and dissemination of domain specific information. These are referred to as Core Activities and are funded by the IAC sponsor. A brief description of these activities follows in Sections 4.1 through 4.4.

4.1 Information Collection

A major activity would be to pull together the many and diverse data and information sources that currently exist in various forms and in various places. As a result of this activity, the IAC would be the central repository within the Government for radar signal/data processing information, reports, conference/workshop proceedings, tools, algorithms, and techniques. The IAC will organize and catalog all of its information holdings. Initially this information would come from AFRL/SN personnel and projects. The IAC will also proactively collaborate with other agencies such as NRL, ARL, and DARPA to assemble a world-class information resource. The IAC will search out other web resources for its holdings – it will not duplicate these holdings -- but rather maintain links to these web resources. The IAC will also collaborate with international centers, universities, and other centers of expertise to gain access to the latest information and technologies. The IAC will participate in professional and technical activities sponsored by national and international societies and associations. It will maintain a database of subject matter experts (SME) with which it can collaborate. When deemed necessary, the IAC will sponsor and conduct workshops and conferences to collect new information and findings in particular areas.

Examples of information sources include: a) analysis tools such as RLSTAP, b) sensor specific system level databases such as MCARM, c) component level data such as tube specs, d) environmental data such as DTED, e) signal processing algorithms such as those for CFAR/detection, f) conference, journal, and trade magazine publications. The goal is to assemble all the existing information (data, analysis tools, reports, research results, computer codes, etc.) so that it is readily available for use by those who need it to carry out their mission.

4.2 Information Processing and Management

This activity involves the organization and development of the retrieval and dissemination methodologies for the collected source information. This means the development of an information support system that will contain bibliographic citations, numeric data, graphic images, models and simulations, and other scientific and technical information related to radar signal and data processing. This information system must be compatible to the extent possible with the retrieval requirements of the anticipated IAC user base.

4.3 Information Analysis

In anticipation of and in response to technical inquiries from the user community, the IAC will have obtained and analyzed the appropriate scientific and technical information. This will enable the IAC to distribute various products and offer various consulting services. In providing the analytical evaluative technical support, often the IAC will need to fill the gaps identified in the knowledge base by creating the missing information by analysis and/or synthesis or where appropriate, by providing input to the relevant military technology programs. In order to accomplish this, the IAC will employ domain knowledgeable technical experts on its staff with the credentials and tools to perform sophisticated analyses. As noted, one of the major benefits of the IAC will be the ability to proactively analyze the state-of-the-art and identify technology gaps in the knowledge base. This in turn can be used to identify future research and development activities by AFRL/SN and data collection activities by the IAC.

4.4 Information Dissemination

An important of function of any IAC is the dissemination of its products and services. This includes technical inquiry answers, abstracts, handbooks, current awareness products, bibliographies, new technology briefs, survey reports, databases, handbooks, state-of-the-art reports, and technical area task reports. The IAC will maintain a web site containing the latest information and products form the IAC.

4.5 Technical Area Tasks (TAT)

The previous sections, 4.1 through 4.4, represent "core" functions of the IAC. The IAC sponsor typically funds "core" functions. Most IAC contracts also include an IDIQ (Indefinite Delivery/Indefinite Quantity) portion

referred to as Technical Area Tasks or TATs. TATs are separately funded by users that wish to employ expertise of the IAC on their particular problem. TATs can run from tens of thousands of dollars to millions of dollars and can run from a few months to several years. TATs are like separate contracts in that they have deliverables and separate schedules. Outputs of the TATs are placed in the IACs holdings. Sections 4.5.1 through 4.5.7 are typical TATS that would fall under the purview of the proposed IAC.

4.5.1 Sensor System Specification Development

An example of a TAT is a top down analysis to develop a system requirements specification based upon one or more mission needs statements. Modern radar signal processing precludes the previous approach of using 'rules of thumb' and simple analyses, such as, the radar range equation and fixed loss budgets. For systems with advanced multiple-channel signal processing, site-specific and/or platform-specific analysis of a radar using the proposed system specifications must be accomplished so that an audit trail between the mission requirements and system requirements can be maintained. Recent research and development activity has focused on tools and techniques for site-specific simulation analysis beginning with the creation of realistic (including platform-specific effects) multi-channel/multi-pulse radar data for targets in clutter and jamming, continuing with high fidelity adaptive processing for clutter and jamming rejection and target detection via space-time adaptive processing (STAP), constant false alarm rate (CFAR) threshold processing followed by track formation and weapons handoff. The system specification audit trail must relate mission requirements (threat targets, clutter environment, jamming) to sensor system requirements (detection and track performance).

4.5.2 Simulation Based Acquisition (SBA)

During the phases of the acquisition process high-fidelity sensor simulations are critical. A very important example would be the evaluation of competing concepts during proposal evaluation. The performance claimed by the various proposing contractors will be a function of a combination of advanced radar signal processing techniques. The evaluation will require the simulation of those concepts in site-specific and platform-specific configurations. It is also important that these evaluations be consistent in terms of the higher-order interactions. The IAC would provide that consistency.

4.5.3 System Design

Contractors designing radar concepts during their proposal evaluation would require the same high-fidelity simulations that were needed in the previous examples. The IAC would provide a source of that capability that would be consistent across contractors. The format of inputs could be provided in the RFP. This would also support the previous example because the data provided in the proposal would be easily implemented in the simulations because it was specified in the RFP.

4.5.4 System Development

During the development of advanced radars both the contractor and the government will require the same level of analysis that was discussed in the previous examples.

4.5.5 Scenario Simulation

Military users of advanced radar systems need to understand their performance in their terms. The must understand how well the radar will perform in terms like threats killed or resources protected. For complex interactive systems with many advanced sensors, this type of evaluation is accomplished using campaign, mission-area or scenario simulations. For these high-level simulations to have the necessary fidelity they must be interfaced with the high-fidelity sensor simulations of the IAC. The IAC simulations, with their supporting data, can generate multi-dimensional databases that will support the scenario simulations and thus give the user information in his terms.

4.5.6 Mission Planning

Advanced radar systems will give the fighting forces much more flexibility of operations than do present radars. This makes the mission planning and post-mission analysis phases of missions more complex. The databases and high-fidelity simulations of the IAC can be employed in support of these analyses. It will be possible to plan a mission in detail. Consideration can be given to the specific location of the mission and intelligence data as to the configuration of enemy resources can be included.

4.5.7 Sensor Interoperability

Future missions against enemy with increased capability will require integration of input from multiple sensors. Optimum use of these multiple sensors requires detailed analysis with high-fidelity sensor simulations to insure that the sensors do not interfere with each other, provide consistent data and are used most efficiently.

These represent readily apparent and important technical tasks that could be useful activities of the proposed IAC. It is not difficult to envision other tasks that could be requested by the potential user community. With the databases in place, access to the latest tools, algorithms, and techniques, the IAC would be ready to assist the radar community in carrying out its mission.

5.0 SUMMARY

In this report, the idea of an authoritative source for information focused on radar signal and data processing is developed. The manifestation of this idea could take the form of a DoD sponsored Information Analysis Center. Such a facility could provide valuable service to the DoD by consolidating, organizing, and managing a currently dispersed and voluminous database of techniques, tools, algorithms, and other information. Secondly, and equally important, is the potential for such a facility to provide analytical and other technical support to system developers and mission planners. Thirdly, because of the access that the facility would have to large quantities of tools and information, it would be in a unique position to guide research and development programs. The opportunity to analyze the state-of-the-art and practice and identify technical and functional gaps in technology would be of significant benefit to the DoD.

It is recommended that an effort be initiated to determine the feasibility of establishing an information analysis center devoted to radar signal and data processing. The effort would have the following objectives:

- Identify competing entities, if any
- Determine potential market size (user community, annual revenues, etc.)
- Estimate start up costs
- Identify potential sponsors
- Outline an implementation strategy

APPENDIX; List of Abbreviations

RLSTAP	Research Laboratory Space Time Adaptive Processing
WIPL-D	Wires, Plates, and Dielectrics
MCARM	Multi-channel Airborne Radar Measurement
GPR	Ground Penetrating Radar
NRL/P3	Naval Research Lab/P3 Aircraft Radar Measurements
FOPEN	Foliage Penetration
AASP	Advanced Airborne Surveillance Program
TTRDP	Tri-National Technology R&D Programme
APTI	Adaptive Processing Technology Initiative
T/R	Transmitter/Receiver
TAT	Technical Area Task
SBA	Simulation Based Acquisition
ARL	Army Research Lab
CFAR	Constant False Alarm Rate
DTED	Digital Terrain Elevation Data
DFAD	Digital Feature Analysis Data
MAPSTAP	Map Space Time Adaptive Processing
MiST	Multi Intelligence Simulation Tool
BRADS	Bistatic Radar Simulation
SMS	Signal Modeling and Simulation
IPSART	Integrated Precision Synthetic Aperture Radar Targeting